Nuclear Safeguards and Security:
Messübungen Für Die Allgemeine Gamma Spektroskopie, ITU 2008.

NUCLEONICA:
A WEB PORTAL FOR THE NUCLEAR SCIENCES

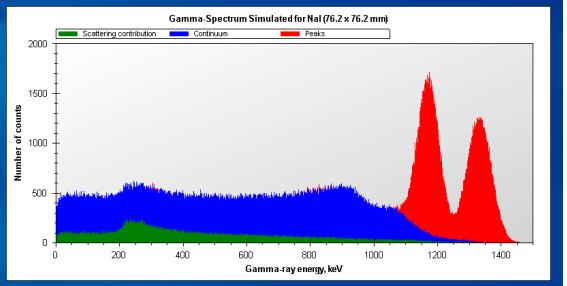
J. MAGILL

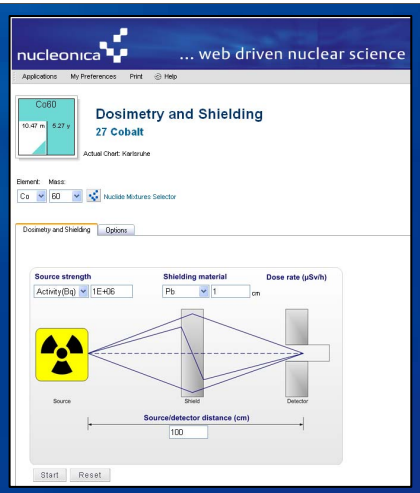
European Commission, Joint Research Centre,
Institute for Transuranium Elements,
Postfach 2340, 76125 Karlsruhe, Germany

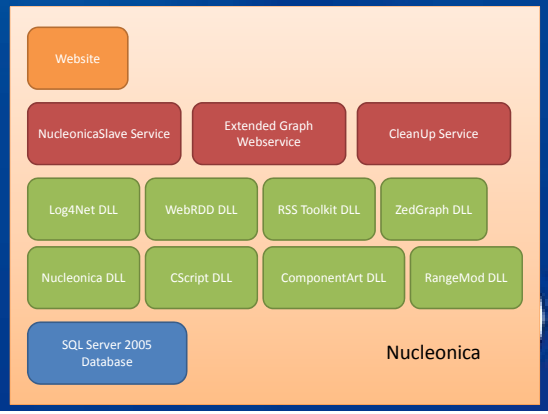
nucleonica

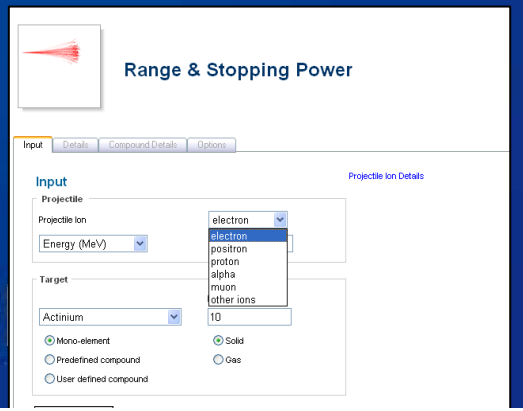
NUCLEONICA:

- OVERVIEW
- AN INTERACTIVE WEB ACCESSIBLE GAMMA-SPECTRUM SIMULATION
- INTERACTIVE, WEB-BASED DOSIMETRY AND SHIELDING CALCULATIONS WITH NUCLEONICA
- RANGE AND STOPPING POWER CALCULATIONS IN NUCLEONICA
- NUCLEONICA – SOFTWARE DESIGN PATTERNS
- NUCLEONICA SCRIPTING
- THE KARLSRUHE NUCLIDE CHART: An educational tool for the nuclear science community









Nucleonica…

Institute for Transuranium Elements

nucleonica … web driven nuclear science

Sunday, November 18, 2007

Home

username •••••••• Login

- Welcome
- Products & Prices
- Free Access
- Training Courses
- Educational Resources
- Karlsruhe Nuclide Chart
- News Releases
- Ask an Expert
- About Us
- Contact

Nucleonica - web driven nuclear science

NUCLEONICA is a new nuclear science web portal from the European Commission's Joint Research Centre. The portal provides a customisable, integrated environment and collaboration platform for the nuclear sciences using the latest internet "Web 2.0" dynamic technology.

NUCLEONICA is aimed at professionals, academics and students working with radionuclides in fields as diverse as the life sciences (e.g. biology, medicine, agriculture), the earth sciences (geology, meteorology, environmental science) and the more traditional disciplines such as nuclear power, health physics and radiation protection, nuclear and radiochemistry, and astrophysics. It is also used as a knowledge management tool to preserve nuclear knowledge built up over many decades by creating modern web-based versions of so-called legacy computer codes.

NUCLEONICA provides "software as a service" on the web rather than through installed software, adding a greater level of stability and security and avoiding version compatibility and update problems. In addition, all **NUCLEONICA's** web applications are browser and operating system independent and can therefore be accessed by most web browsers.

NUCLEONICA offers the following main features:

» **Data Centre:** Online interactive nuclide charts. Reference data and searchable databases for internationally evaluated nuclear data. Library creation software

NUCLEONICA HOT TOPICS

» Open Call for JRC Traineeships

November 14, 2007

ITU's first open call for JRC-Traineeships has been published on our website. The deadline for applications is 6 December 2007 (midnight). In particular we have a position for assistance in the development of an electronic version of the Karlsruhe

JRC EUROPEAN COMMISSION

Institute for Transuranium Elements

NUCLEAR NEWS

French FM: France is not ruling out a military strike on Iran

NOV 18 Even though in Tehran the IAEA's report was described as a "political victory" that may prevent the intensifying of international sanctions, Kouchner says that "for now Iran persists in not meeting it […]

Iran: UNSC interference illegal

NOV 18 Mohammad Saeedi, a senior Iranian nuclear official has said insistence on pursuing Iran's nuclear program at the Security Council lacks legal grounds, PressTV reported. […]

Iran says ready to act if attacked …

NOV 18 LONDON, November 18 (IranMania) - Hardline Iranian President Mahmoud Ahmadinejad said Iran was ready to respond if attacked, but played down the prospect of war with the United States, Reuters reporte […]

'Safe' uranium that left a town contaminated

NOV 18 It is 50 years since Tony Ciarfello and his friends used the yard of a depleted uranium weapons factory as their playground in Colonie, a suburb of Albany in upstate New York state. "There wasn't no f […]

Chavez dealing pain to Spain

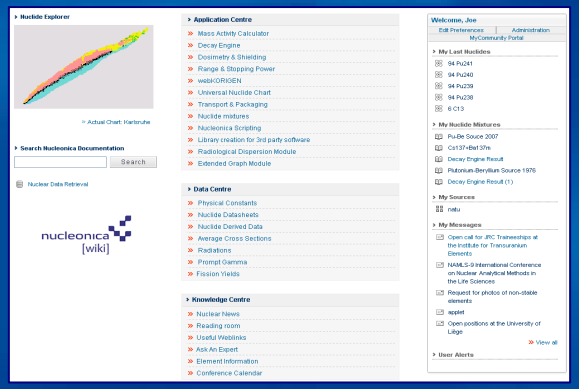
NOV 18 Chavez, who has nationalised large parts of the economy this year under his self-styled socialist "revolution", said last week he will revise diplomatic and business ties with the

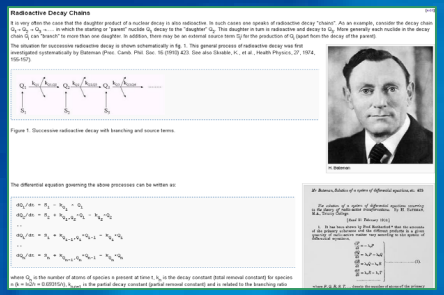
Nuclear Science Data & Applications

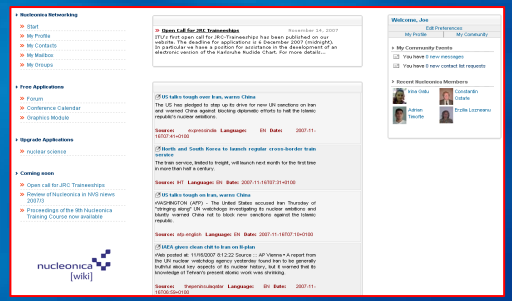
Nucleonica Wiki (CMS)

Networking with Nucleonica

Training Courses

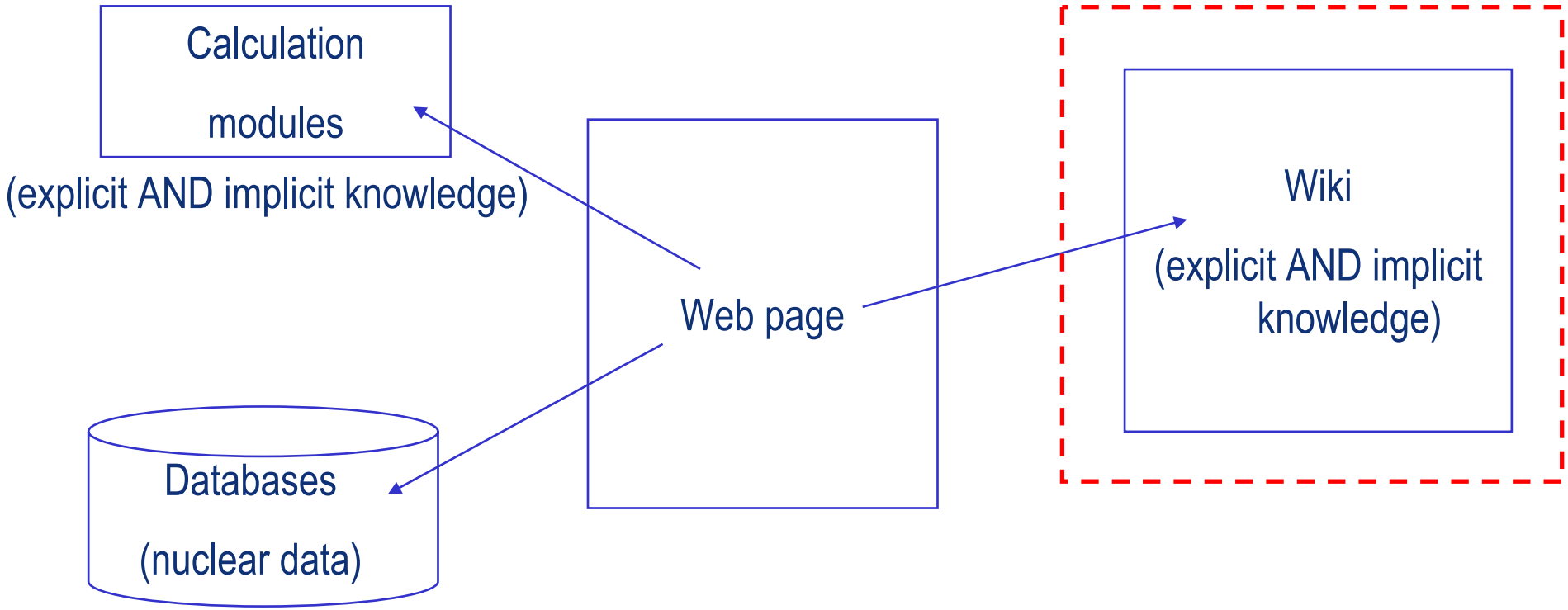






nucleonica

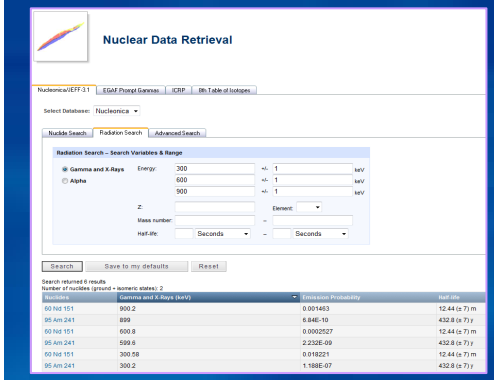
Nucleonica Architecture & Logical Structure…

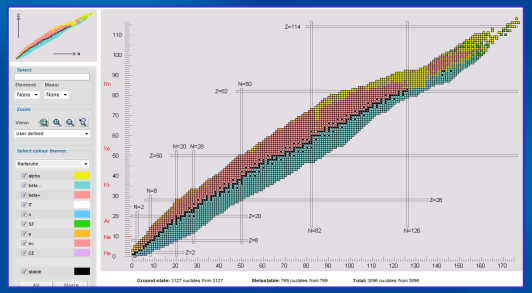


The NUCLEONICA Structure

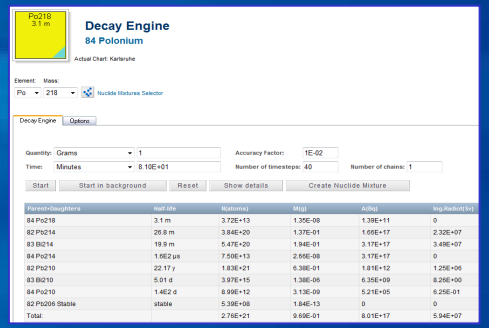
Nuclear science portal …

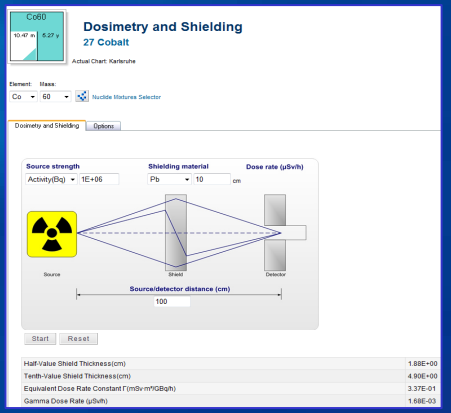
Data centre…

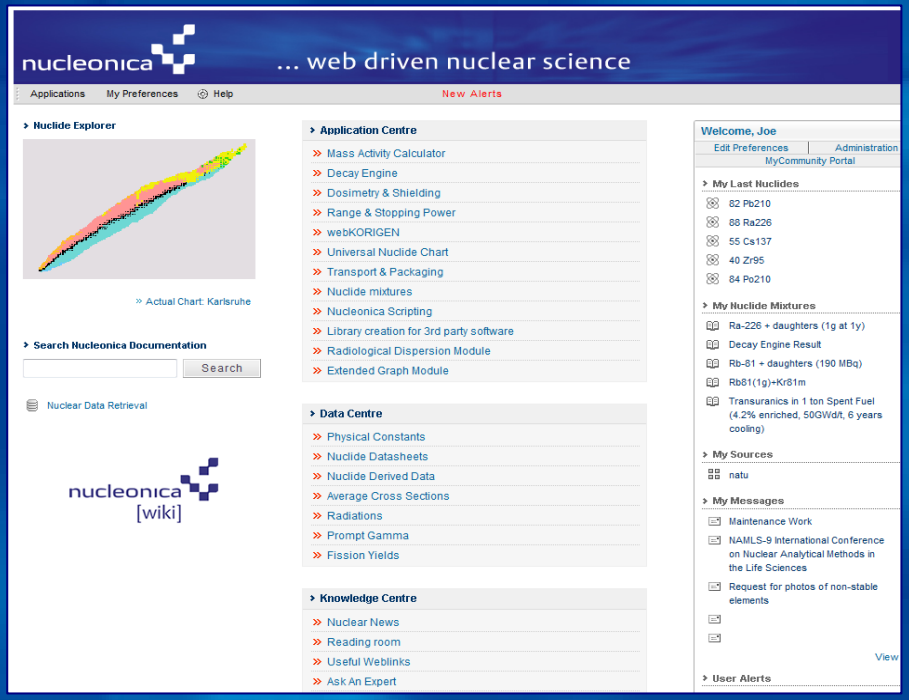




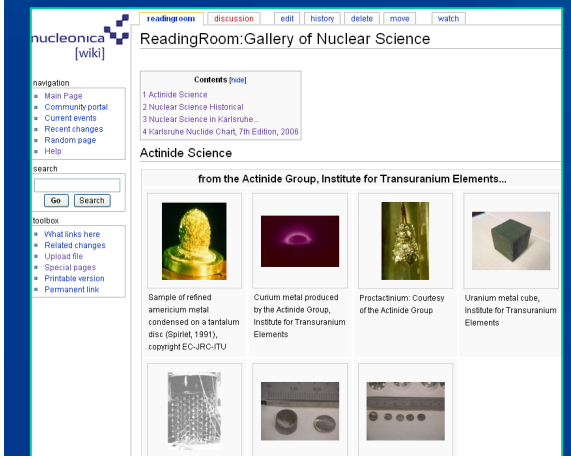
Applications centre…



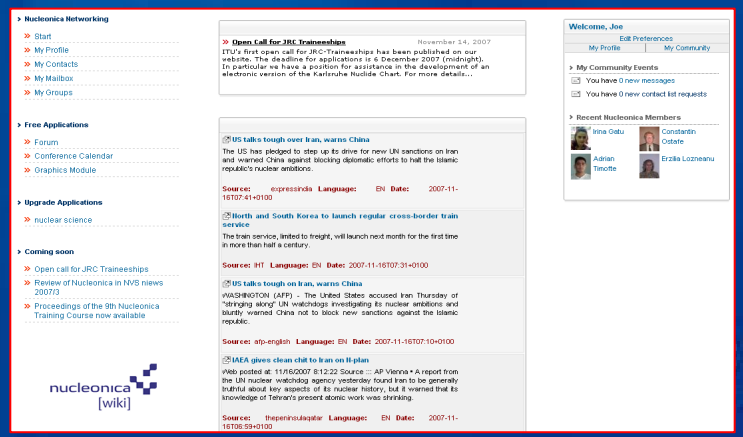


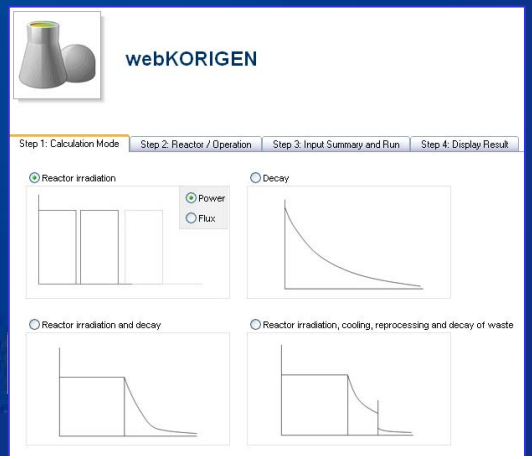


Knowledge centre…



Networking centre…



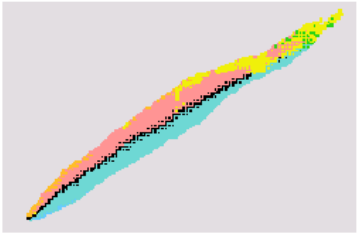


Nuclear science applications…

nucleonica … web driven nuclear science

Applications | My Preferences | Help

Nuclide Explorer



» Actual Chart: Karlsruhe

Search Nucleonica Documentation

Search

Nuclear Data Retrieval

nucleonica [wiki]

Application Centre

- Mass Activity Calculator
- Decay Engine
- Dosimetry & Shielding
- Range & Stopping Power
- webKORIGEN
- Universal Nuclide Chart
- Transport & Packaging
- Nuclide mixtures
- Nucleonica Scripting
- Library creation for 3rd party software
- Radiological Dispersion Module
- Extended Graph Module

Data Centre

- Physical Constants
- Nuclide Datasheets
- Nuclide Derived Data
- Average Cross Sections
- Radiations
- Prompt Gamma
- Fission Yields

Knowledge Centre

- Nuclear News
- Reading room
- Useful Weblinks
- Ask An Expert
- Element Information
- Conference Calendar

Welcome, Joe

Edit Preferences | Administration

MyCommunity Portal

My Last Nuclides

- 90 Th232
- 90 Th231
- 94 Pu239
- 92 U235
- 25 Mn52

My Nuclide Mixtures

- Pu238+daughter (100g @50y)
- Natural Uranium
- Cs137 + Ba137m
- U232+Co60
- Transuranics in 1 ton Spent Fuel (4.2% enriched, 50GWd/t, 6 years cooling)

My Sources

- Pu239 1 g
- natu

My Messages

- Thanks!
- About my group and information
- Photo Change
- Open call for JRC Traineeships at the Institute for Transuranium Elements
- NAMLS-9 International Conference on Nuclear Analytical Methods in the Life Sciences

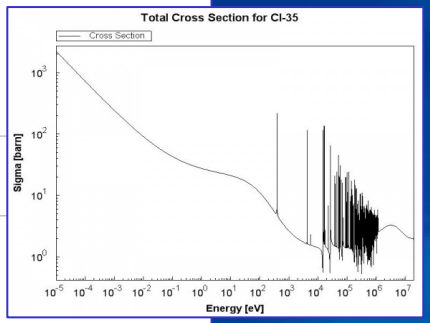
» View

User Alerts

- Task completed (DecayEngine: Uranium 238)

» View

Nuclear Data Retrieval



Nucleonica/JEFF-3.1 | EGAF Prompt Gammas | ICRP | 8th Table of Isotopes

Select Database: Nucleonica

Nuclide Search | Radiation Search | Advanced Search

Radiation Search – Search Variables & Range

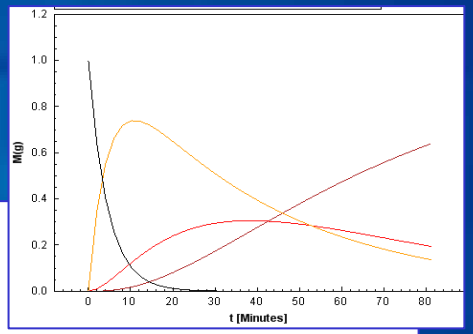
Gamma and X-Rays / Alpha

Energy:	300	+/-	1	keV
	600	+/-	1	keV
	900	+/-	1	keV
Z:		Element:		
Mass number:		–		
Half-life:	Seconds	–	Seconds	

Search | Save to my defaults | Reset

Search returned 6 results
Number of nuclides (ground + isomeric states): 2

Nuclides	Gamma and X-Rays (keV)	Emission Probability	Half-life
60 Nd 151	900.2	0.001463	12.44 (± 7) m
95 Am 241	899	6.84E-10	432.8 (± 7) y
60 Nd 151	600.8	0.0002527	12.44 (± 7) m
95 Am 241	599.6	2.232E-09	432.8 (± 7) y
60 Nd 151	300.58	0.018221	12.44 (± 7) m
95 Am 241	300.2	1.188E-07	432.8 (± 7) y



Decay Engine

Po218 3.1 m

84 Polonium

Actual Chart: Karlsruhe

Element: Po Mass: 218 Nuclide Mixtures Selector

Decay Engine | Options

Quantity: Grams 1 Accuracy Factor: 1E-02

Time: Minutes 8.10E+01 Number of timesteps: 40 Number of chains: 1

Start | Start in background | Reset | Show details | Create Nuclide Mixture

Parent+Daughters	Half-life	N(atoms)	M(g)	A(Bq)	Ing.Radiot(Sv)
84 Po218	3.1 m	3.72E+13	1.35E-08	1.39E+11	0
82 Pb214	26.8 m	3.84E+20	1.37E-01	1.66E+17	2.32E+07
83 Bi214	19.9 m	5.47E+20	1.94E-01	3.17E+17	3.49E+07
84 Po214	1.6E2 µs	7.50E+13	2.66E-08	3.17E+17	0
82 Pb210	22.17 y	1.83E+21	6.38E-01	1.81E+12	1.25E+06
83 Bi210	5.01 d	3.97E+15	1.38E-06	6.35E+09	8.26E+00
84 Po210	1.4E2 d	8.99E+12	3.13E-09	5.21E+05	6.25E-01
82 Pb206 Stable	stable	5.39E+08	1.84E-13	0	0
Total:		2.76E+21	9.69E-01	8.01E+17	5.94E+07

Dosimetry and Shielding

Co60 10.47 m 5.27 y

27 Cobalt

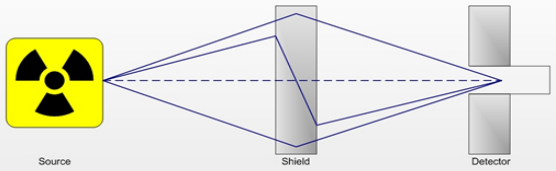
Actual Chart: Karlsruhe

Element: Co Mass: 60 Nuclide Mixtures Selector

Dosimetry and Shielding | Options

Source strength **Shielding material** **Dose rate (µSv/h)**

Activity(Bq) 1E+06 Pb 10 cm



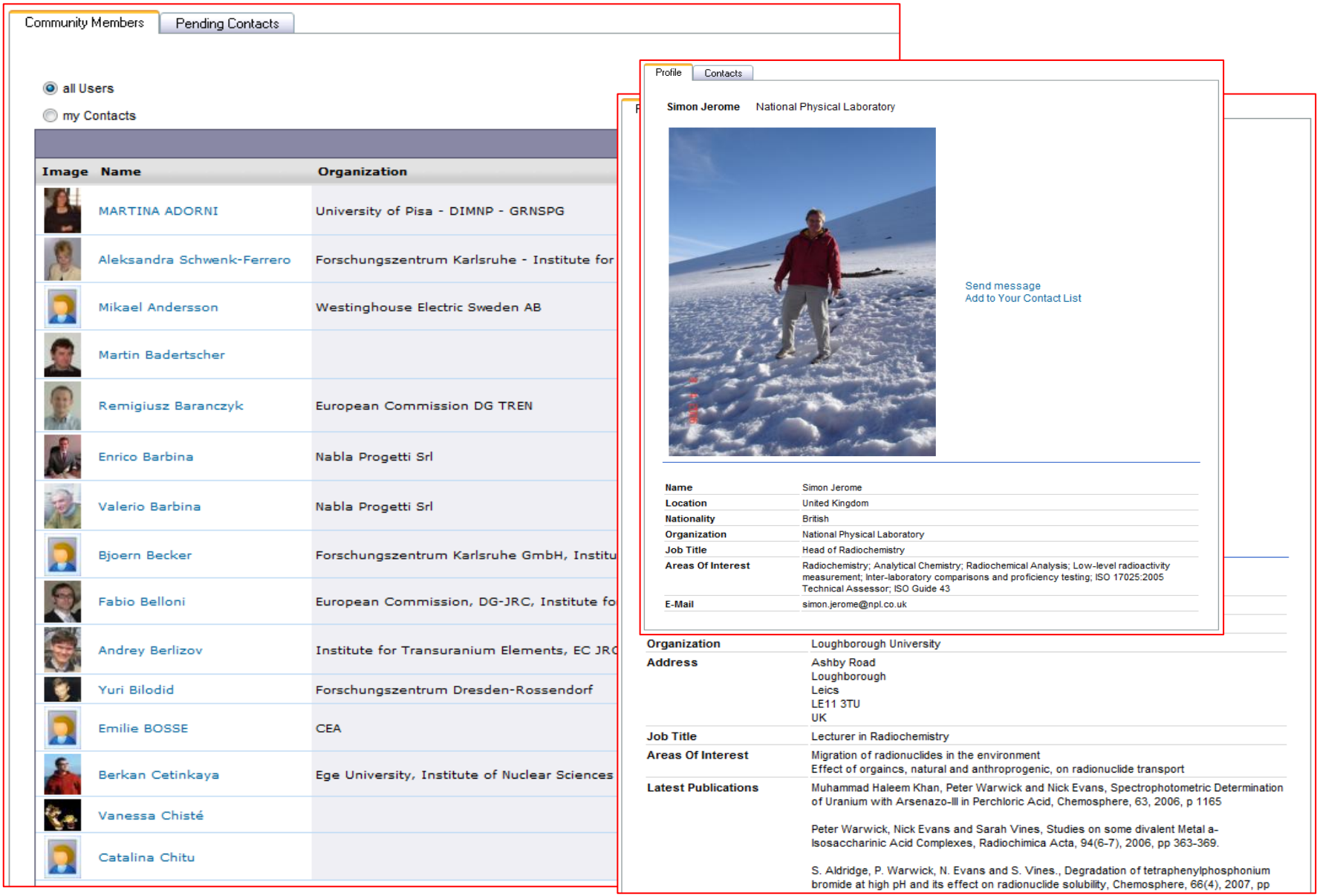
Source/detector distance (cm)

100

Start | Reset

Half-Value Shield Thickness(cm)	1.88E+00
Tenth-Value Shield Thickness(cm)	4.90E+00

nucleonica


Community Members
Pending Contacts
all Users
my Contacts
Image
Name
Organization
MARTINA ADORNI
University of Pisa - DIMNP - GRNSPG
Aleksandra Schwenk-Ferrero
Forschungszentrum Karlsruhe - Institute for
Mikael Andersson
Westinghouse Electric Sweden AB
Martin Badertscher
Remigiusz Baranczyk
European Commission DG TREN
Enrico Barbina
Nabla Progetti Srl
Valerio Barbina
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Bjoern Becker
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Andrey Berlizov
Institute for Transuranium Elements, EC JRC
Yuri Bilodid
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Emilie BOSSE
CEA
Berkan Cetinkaya
Ege University, Institute of Nuclear Sciences
Vanessa Chisté
Catalina Chitu
Profile
Contacts
Simon Jerome
National Physical Laboratory
Send message
Add to Your Contact List
Name
Simon Jerome
Location
United Kingdom
Nationality
British
Organization
National Physical Laboratory
Job Title
Head of Radiochemistry
Areas Of Interest
Radiochemistry; Analytical Chemistry; Radiochemical Analysis; Low-level radioactivity measurement; Inter-laboratory comparisons and proficiency testing; ISO 17025:2005 Technical Assessor; ISO Guide 43
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LE11 3TU
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Job Title
Lecturer in Radiochemistry
Areas Of Interest
Migration of radionuclides in the environment
Effect of orgainics, natural and anthroprogenic, on radionuclide transport
Latest Publications
Muhammad Haleem Khan, Peter Warwick and Nick Evans, Spectrophotometric Determination of Uranium with Arsenazo-III in Perchloric Acid, Chemosphere, 63, 2006, p 1165
Peter Warwick, Nick Evans and Sarah Vines, Studies on some divalent Metal a-Isosaccharinic Acid Complexes, Radiochimica Acta, 94(6-7), 2006, pp 363-369.
S. Aldridge, P. Warwick, N. Evans and S. Vines., Degradation of tetraphenylphosphonium bromide at high pH and its effect on radionuclide solubility, Chemosphere, 66(4), 2007, pp

October 2007 Karlsruhe

[edit]

9th Nuclear Science Training Course with Nucleonica, 25/26th Oct. 2007, Ostendorfhaus, Karlsruhe

The 9th Nuclear Science training course on Radioactivity, Radionuclides and Radiation with Nucleonica was held at the Ostendorfhaus, Karlsruhe from the 25th to 26th October, 2007. The two-day course provided a general introduction to the recently released Nucleonica: the new science networking and applications portal. Nucleonica is a powerful and versatile web-based software package for the nuclear science community. With examples and exercises, a variety of core and topical issues in nuclear science and technology were presented by experts in their respective fields.

A total of twenty-nine participants, around half of them women, with a diverse range of backgrounds attended the course. There were participants from Azerbaijan, Belgium, Bulgaria, Czech Republic, Poland, Romania and Turkey. In addition there were 10 participants form the Institute for Transuranium Elements. Among them were students, academics and industry professionals from fields such as nuclear medicine, radiation protection, environmental radioactivity and reactor physics.

Final Agenda 25th Oct. 2007

How to get from the hotel to the conference training centre

Links to the presentations and exercises:

Networking with Nucleonica (J. Magill) Exercises

Nuclear Data (J. Galy) Exercises

Nuclide Charts (C. Normand) Exercises

Decay Engine (A. Berlizov) Exercises

Dosimetry & Shielding (J. Galy) Exercises

Nuclear Forensics & Illicit Trafficking (K. Mayer) Exercises

Overview of the Institute for Transuranium Elements (F. Wastin)

Advanced Nucleonica Features (J. Magill)

Training Course Feedback

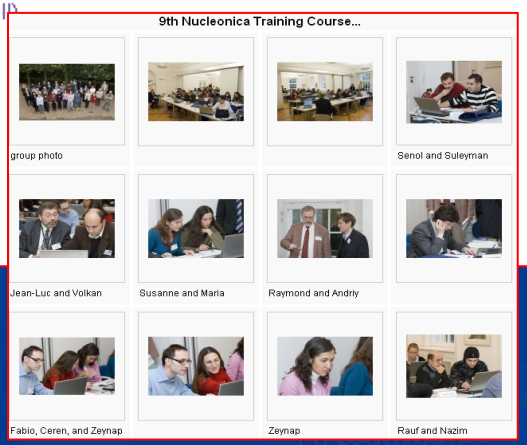
QM Questionnaire

Course Certificate

List of Participants

Gallery

Group Photo Oct. 2007, Ostendorfhaus Karlsruhe



nucleonica

WEB-BASED DOSIMETRY AND SHIELDING CALCULATIONS IN NUCLEONICA

Dosimetry and Shielding in Nucleonica

The intuitive interface of the Dosimetry and Shielding module allows quick and accurate calculations and has been specifically designed to be suitable for use by professionals and students in the nuclear science and technology field.

The dose rate is calculated using the point source kernel approach and is given by:

$$\frac{dH(r)}{dt} = \frac{A}{4\pi r^2} \cdot \sum_i \left[E_i \cdot P_i \cdot \left(\frac{\mu}{\rho} \right)_i^{tissue} \cdot B_i \cdot \exp\left[-\left(\frac{\mu}{\rho} \right)_i^{shield} \cdot \rho d \right] \right]$$

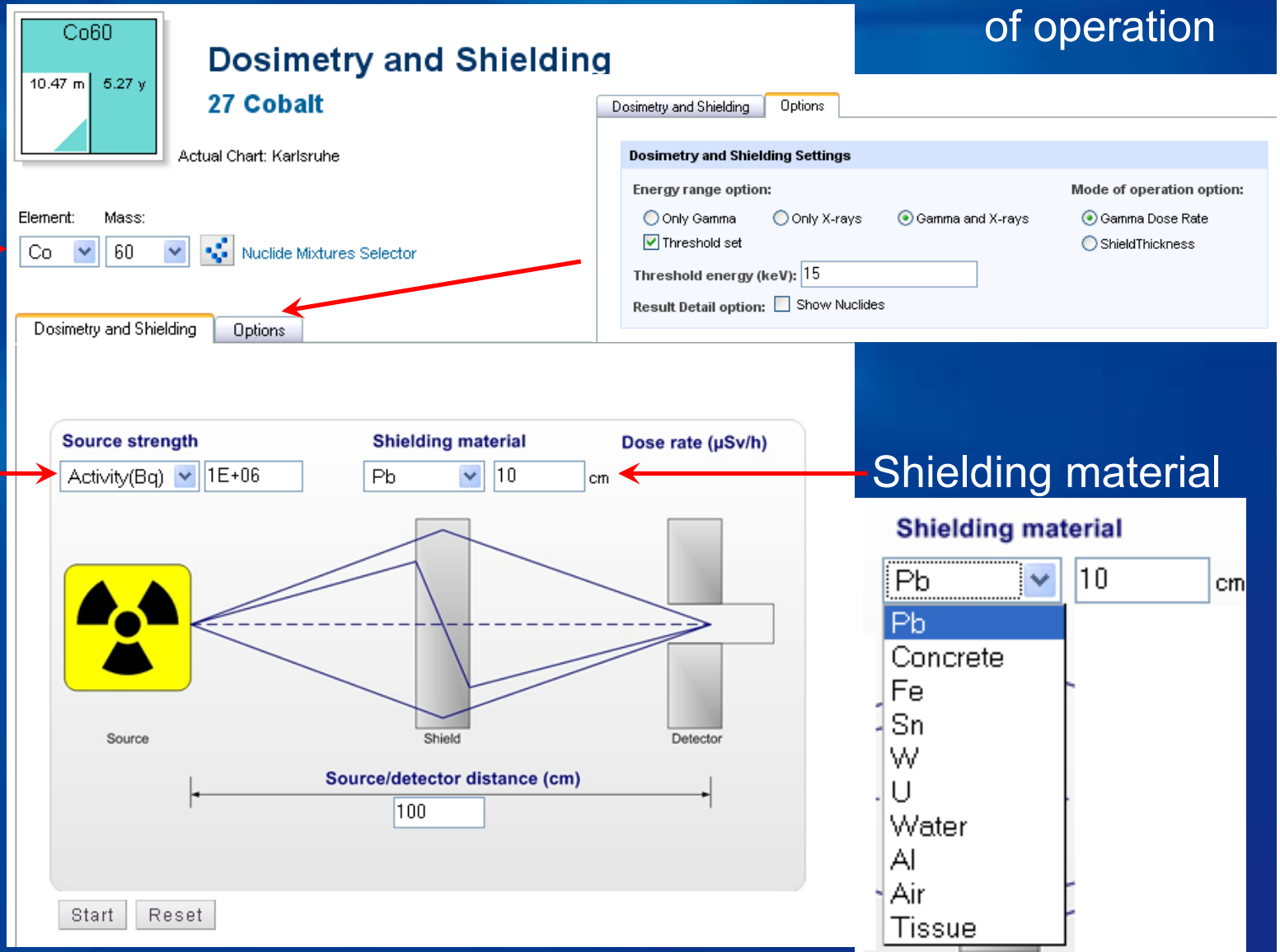
Main interface

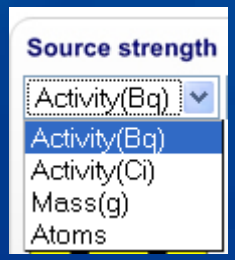
Options/Modes of operation

Source:

Source strength:

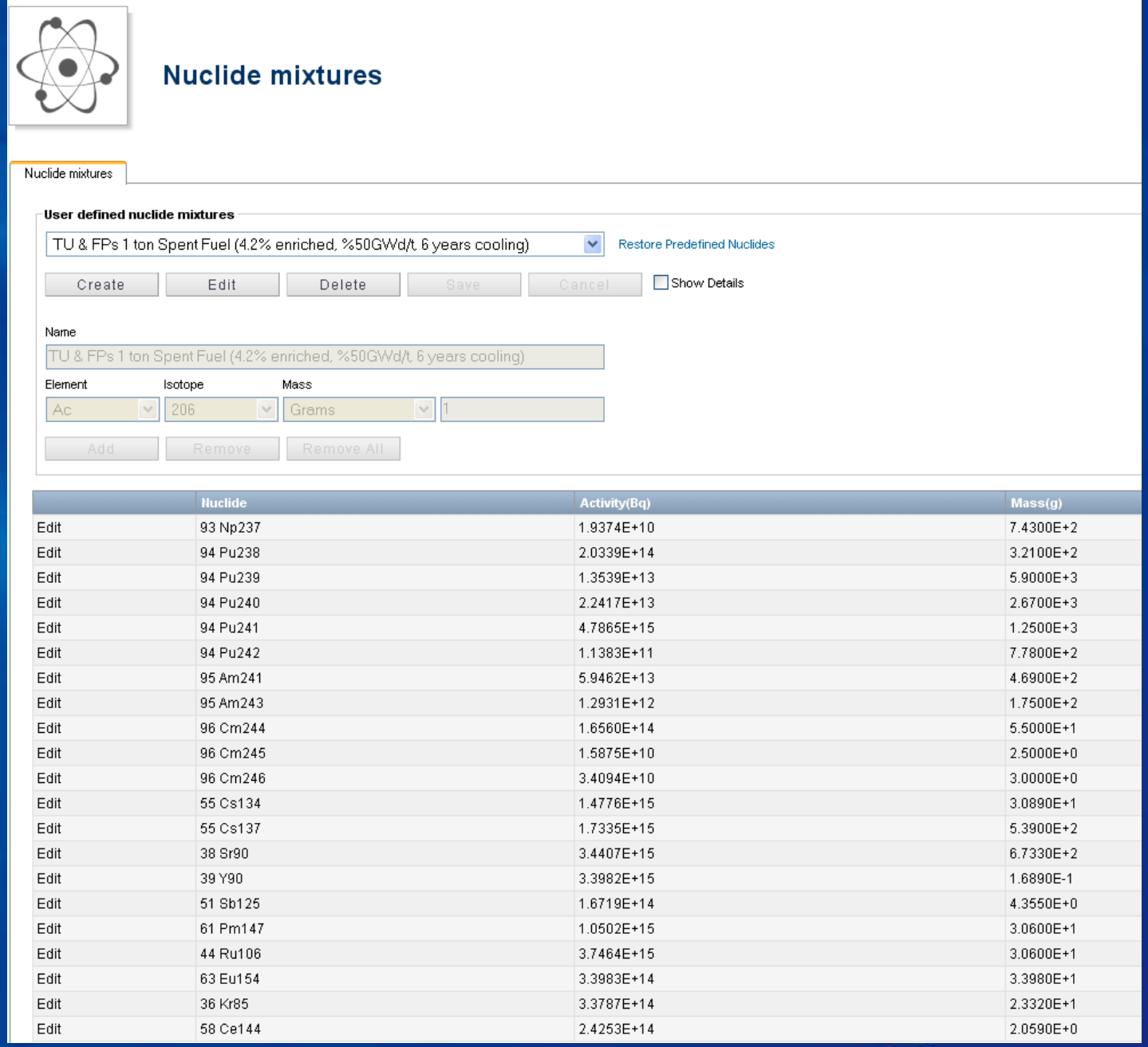
Shielding material





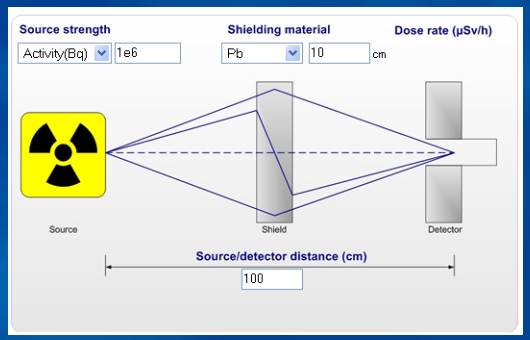
Source selection

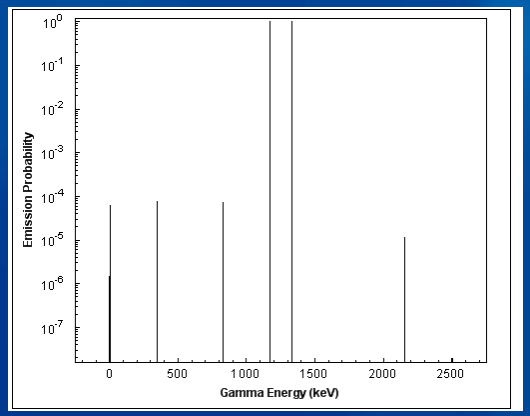
Mixtures:



	Nuclide	Activity(Bq)	Mass(g)
Edit	93 Np237	1.9374E+10	7.4300E+2
Edit	94 Pu238	2.0339E+14	3.2100E+2
Edit	94 Pu239	1.3539E+13	5.9000E+3
Edit	94 Pu240	2.2417E+13	2.6700E+3
Edit	94 Pu241	4.7865E+15	1.2500E+3
Edit	94 Pu242	1.1383E+11	7.7800E+2
Edit	95 Am241	5.9462E+13	4.6900E+2
Edit	95 Am243	1.2931E+12	1.7500E+2
Edit	96 Cm244	1.6560E+14	5.5000E+1
Edit	96 Cm245	1.5875E+10	2.5000E+0
Edit	96 Cm246	3.4094E+10	3.0000E+0
Edit	55 Cs134	1.4776E+15	3.0890E+1
Edit	55 Cs137	1.7335E+15	5.3900E+2
Edit	38 Sr90	3.4407E+15	6.7330E+2
Edit	39 Y90	3.3982E+15	1.6890E-1
Edit	51 Sb125	1.6719E+14	4.3550E+0
Edit	61 Pm147	1.0502E+15	3.0600E+1
Edit	44 Ru106	3.7464E+15	3.0600E+1
Edit	63 Eu154	3.3983E+14	3.3980E+1
Edit	36 Kr85	3.3787E+14	2.3320E+1
Edit	58 Ce144	2.4253E+14	2.0590E+0

Results:





Half-Value Shield Thickness(cm)	1.88E+00
Tenth-Value Shield Thickness(cm)	4.90E+00
Equivalent Dose Rate Constant Γ(mSv·m²/GBq/h)	3.37E-01
Gamma Dose Rate (µSv/h)	1.68E-03

Download Excel CSV Separator: Semicolon (";") Use field qualifier (")

Number of lines (γ):	6	ΣE.P.(γ):	2.50E+06
Number of lines (X):	4	ΣE.P.(X):	8.35E-01
Number of lines (γ+X):	10	ΣE.P.(total):	2.50E+06

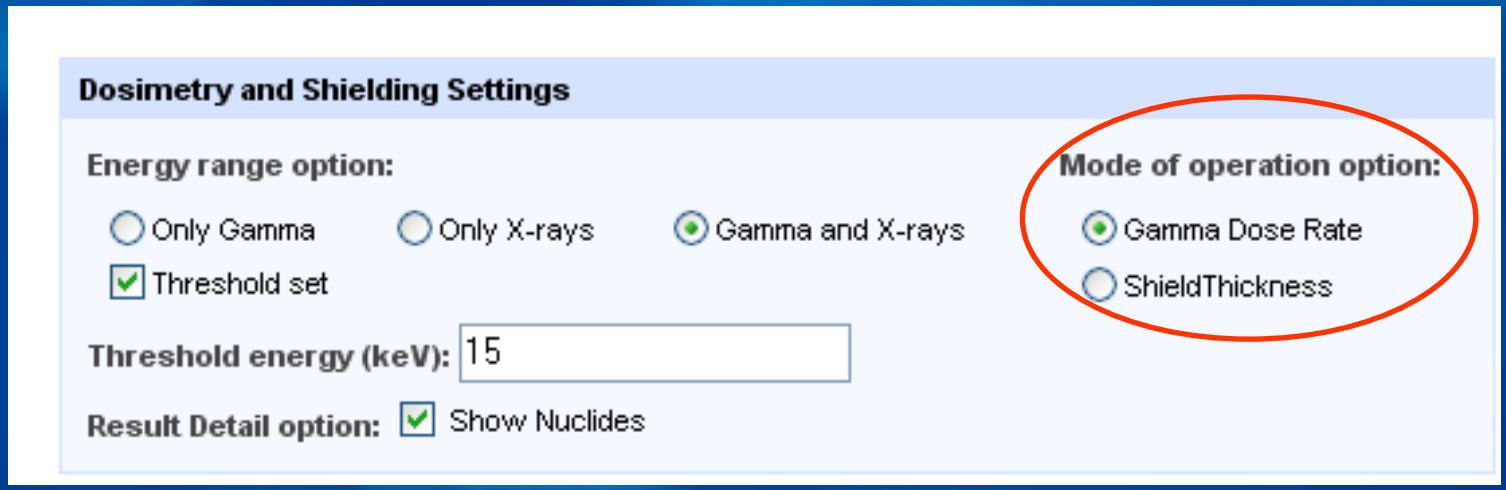
Download Excel CSV Separator: Semicolon (";") Use field qualifier (")

Component	Activity	Mass
27 Co 60	1.00E+06	2.39E-08

Nuclide	Gamma Energy (MeV)	Emission Probability P (per disintegration)	Mass Attenuation Coefficient (shielding)(cm2/g)	Number of Mean Free Path (µd)	Build-up Factor	Mass Absortion Coefficient (tissue)(cm2/g)	Gamma Dose Rate (µSv/h)
27 Co 60	1.33E+00	1.00E+00	5.64E-02	6.40E+00	3.68E+00	2.89E-02	1.08E-03
27 Co 60	1.17E+00	9.99E-01	6.20E-02	7.04E+00	4.30E+00	2.98E-02	6.02E-04
27 Co 60	8.26E-01	7.60E-05	8.59E-02	9.75E+00	4.10E+00	3.16E-02	2.18E-09
27 Co 60	3.47E-01	7.50E-05	3.05E-01	3.46E+01	2.30E+00	3.21E-02	0
27 Co 60	7.48E-03	6.44E-05	2.71E+02	3.07E+04	1	1.22E+01	0
27 Co 60	7.46E-03	3.27E-05	2.72E+02	3.09E+04	1	1.23E+01	0
27 Co 60	8.26E-03	1.31E-05	2.11E+02	2.40E+04	1	9.01E+00	0
27 Co 60	2.16E+00	1.20E-05	4.54E-02	5.15E+00	3.90E+00	2.52E-02	6.78E-08
27 Co 60	8.50E-04	1.49E-06	7.16E+03	8.12E+05	1	5.38E+03	0
27 Co 60	2.51E+00	2.00E-08	4.39E-02	4.99E+00	3.35E+00	2.40E-02	1.26E-10

Download Excel CSV Separator: Semicolon (";") Use field qualifier (")

Options and operation modes:



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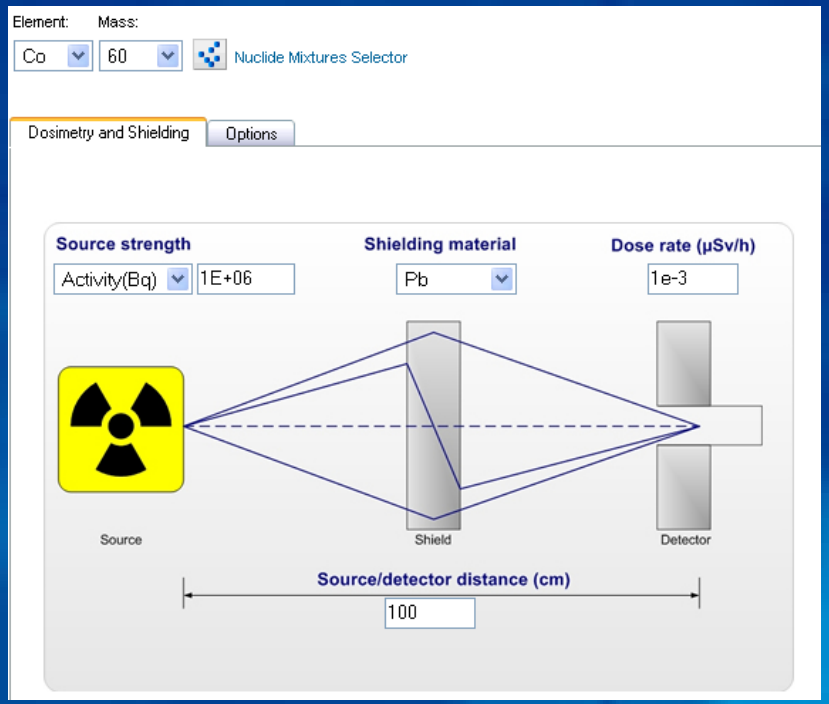

Shield thickness mode:

Half-Value Shield Thickness(cm)	1.88E+00
Tenth-Value Shield Thickness(cm)	4.90E+00
Equivalent Dose Rate Constant Γ(mSv·m²/GBq/h)	3.37E-01
Shielding Thickness| required(cm)	1.09E+01
Resulting Gamma| Dose Rate(μSv/h)	1.00E-03

Gamma Energy (MeV)	Emission Probability P (per disintegration)	Mass Attenuation Coefficient (shielding)(cm²/g)	Number of Mean Free Path(μd)	Build-up Factor	Mass Absorption Coefficient (tissue)(cm²/g)	Gamma Dose Rate(μSv/h)
1.33E+00	1.00E+00	5.64E-02	7.00E+00	4.30E+00	2.89E-02	6.91E-04
1.17E+00	9.99E-01	6.20E-02	7.70E+00	4.30E+00	2.98E-02	3.10E-04
8.26E-01	7.60E-05	8.59E-02	1.07E+01	5.03E+00	3.16E-02	1.07E-09
3.47E-01	7.50E-05	3.05E-01	3.78E+01	2.35E+00	3.21E-02	0
7.48E-03	6.44E-05	2.71E+02	3.36E+04	1	1.22E+01	0
7.46E-03	3.27E-05	2.72E+02	3.38E+04	1	1.23E+01	0
8.26E-03	1.31E-05	2.11E+02	2.63E+04	1	9.01E+00	0
2.16E+00	1.20E-05	4.54E-02	5.63E+00	3.90E+00	2.52E-02	4.17E-08
8.50E-04	1.49E-06	7.16E+03	8.89E+05	1	5.38E+03	0
2.51E+00	2.00E-08	4.39E-02	5.46E+00	3.90E+00	2.40E-02	9.16E-11

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Help:Dosimetry & Shielding

In this section the formalism for dosimetry and shielding calculations is developed. In
the physical basis of radiation dosimetry and shielding.

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μ slope of the absorption curve – the attenuation coefficient.

Since the product μd in the above relation must be dimensionless, if the absorber thickness is measured in cm, then the attenuation coefficient is called the linear attenuation coefficient μ_l and has dimension cm^{-1}. If the thickness d is in g/cm^2 then the attenuation coefficient is called the mass attenuation coefficient μ_m and has units of cm^2/g. The relationship between these coefficients is:

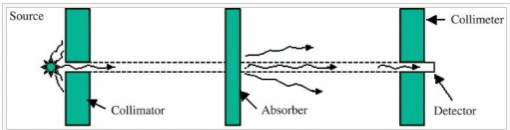


Fig.1. Measurement of the attenuation of gamma radiation under conditions of good geometry. Ideally, the beam should be well collimated, and the source should be as far away as possible from the detector. The absorber should be midway between the source and the detector, and it should be thin enough so that the likelihood of a second interaction between a photon already scattered by the absorber and the absorber is negligible. In addition, there should be no scattering material in the vicinity of the detector

$$\mu_l\ (cm^{-1}) = \mu_m\ (cm^2/g) \cdot \rho\ (g/cm^3)\ ,$$

where ρ is the density of the absorber. The attenuation coefficient is the fraction of the gamma radiation beam attenuation per unit thickness of absorber and is defined as:

$$\mu = -[(\Delta I/I)/\Delta d]_{\Delta d \to 0}\ ,$$

where ΔI/I is the fraction of the gamma radiation attenuated by an absorber of thickness Δd. The attenuation coefficient thus defined is sometimes called the total attenuation coefficient.

Generally, for energies between about 0.75 and 5 MeV, almost all materials have, on a mass basis, about the same gamma radiation attenuation properties. To a first approximation, therefore, shielding properties are approximately proportional to the density of the shielding material. Under conditions of good geometry, the attenuation of a beam of gamma radiation is given therefore by:

$$I = I_0 \cdot \exp(-\mu_l d)$$

or

$$I = I_0 \cdot \exp[(-\mu_l/\rho \cdot \rho d)]\ .$$

However, under conditions of poor geometry, i.e. for a broad beam or for a very thick shield, the above relation underestimates the required shield thickness. It assumes that every photon that interacts with the shield will be removed from the beam and thus will not be available for counting in the detector. Under conditions of poor geometry, as shown in Fig. 2, this assumption is not valid; a significant number of photons may be scattered by the shield into the detector, or photons that had been scattered out of the beam may be scattered back in after a second collision.

The shield thickness for conditions of poor geometry may be estimated by modification of the basic attenuation relation given above through the use of a build-up factor B, i.e.

$$I = B \cdot I_0 \cdot \exp[-(\mu_l/\rho) \cdot (\rho d)]\ .$$

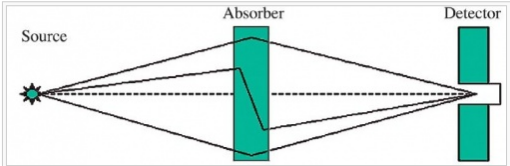


Fig.2. Gamma radiation attenuation under conditions of broad beam geometry showing the effect of photons scattered into the detector

The build-up factor, which is always greater than 1, may be defined as the ratio of the intensity of the radiation, including both the primary and scattered radiation, at any point in a beam, to the intensity of the primary radiation only at that point. Build-up factors have been calculated for various gamma energies and for various absorbers. The build-up factor is in general a function of the total attenuation coefficient, the thickness of the shielding material d, and the energy of the gamma radiation, i.e. $B = B(\mu d, E)$, hence

Scripting language

Dosimetry	Description:	Performs dosimetry calculation
	Return type:	DoseResult
	Parameters:	▪ double quantity ▪ string unitQuantity ("Bq", "Ci", "g", "atoms") ▪ string energyRangeOption (comma seperated string consisting of values "gamma", "xray") ▪ string shieldMaterial, one of the following shield materials: "Pb", "Concrete", "Fe", "Sn", "W", "U", "Water", "Al", "Air", "Tissue" ▪ double distance [cm] ▪ string doseOption, the mode of calculation: "gamma", "thickness" ▪ double thickness [cm] ▪ double threshold [keV]

```
********** U235 Dosimetry **********
HalfValueThickness 9.51E-05
TenthValueThickness 0.03
Eqivalent dose rate constant 0.154
Gamma dose Rate 8.67E-16
Thickness 0
Resulting Gamma dose Rate 0
```

```
int main()
{
	nuclide nuc;
	nuc.Create("U", 235, 0);

	print("********** U235 Dosimetry **********");
	doseResult doseRes;
	doseRes = nuc.Dosimetry(1E6, "Bq", "gamma,xray", "Pb", 100, "gamma", 10, -1);
	print("HalfValueThickness " + doseRes.HalfValueThickness);
	print("TenthValueThickness " + doseRes.TenthValueThickness);
	print("Eqivalent dose rate constant " + doseRes.EquiDoseRateConst);
	print("Gamma dose Rate " + doseRes.GammaDoseRate);
	doseRes = nuc.Dosimetry(1E6, "Bq", "gamma,xray", "Pb", 100, "thickness", 1E-6, 10);
	print("Thickness " + doseRes.Thickness);
	print("Resulting Gamma dose Rate " + doseRes.ResultingGammaDoseRate);
	print("");

	return 0;
}
```

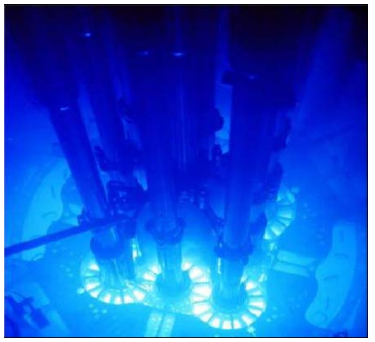
CONCLUSIONS

The Dosimetry and Shielding is:

- ✓ A versatile tool for quick and accurate dosimetry and shielding calculations.
- ✓ It allows the user to calculate gamma dose rates from point sources of single nuclide and mixtures, through a choice of 10 different shield materials. Over 3000 nuclides with more than 53000 gamma lines are available in the database.
- ✓ The intuitive interface allows quick and accurate calculations and has been specifically designed to be suitable for use by professionals and students in nuclear science and technology.
- ✓ Complete implementation in the Nucleonica framework (with Wiki/Help), and can be used within the scripting language.
- ✓ Continuously under development (more shielding material, multiple screens, volumetric sources…)

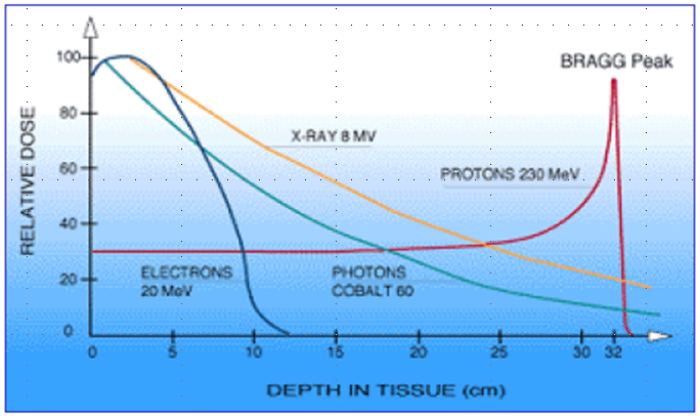
RANGE AND STOPPING POWER CALCULATIONS IN NUCLEONICA

Aurora Borealis: interaction of electrons with oxygen and molecular nitrogen.



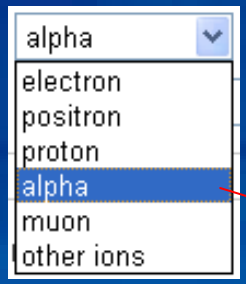
Čerenkov radiation: is radiation emitted when a charged particle) passes through matter at a speed greater than the speed of light in that medium. The characteristic "blue glow" of nuclear reactors is due to Čerenkov radiation.

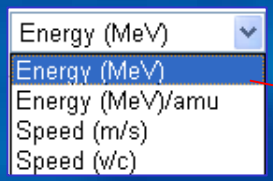
Proton therapy: (used in treatment of tumours): 230 MeV p can penetrate in 32 cm tissue



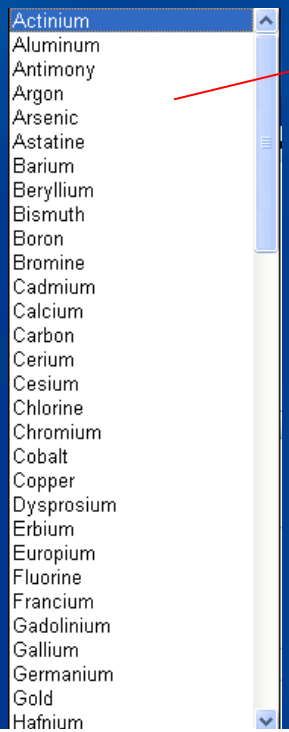
wide application area: ion implantation, fundamental particle physics, nuclear physics, radiation damage, radiology, Rutherford backscattering spectroscopy, and plasma-first wall interaction in a nuclear-fusion reactor

Projectile:

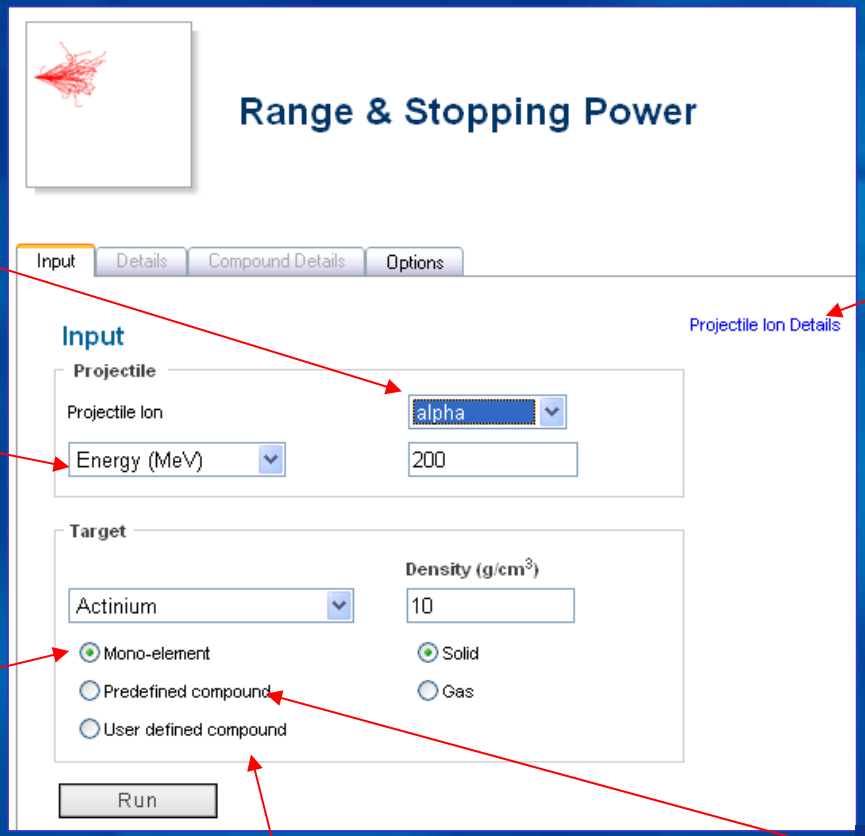




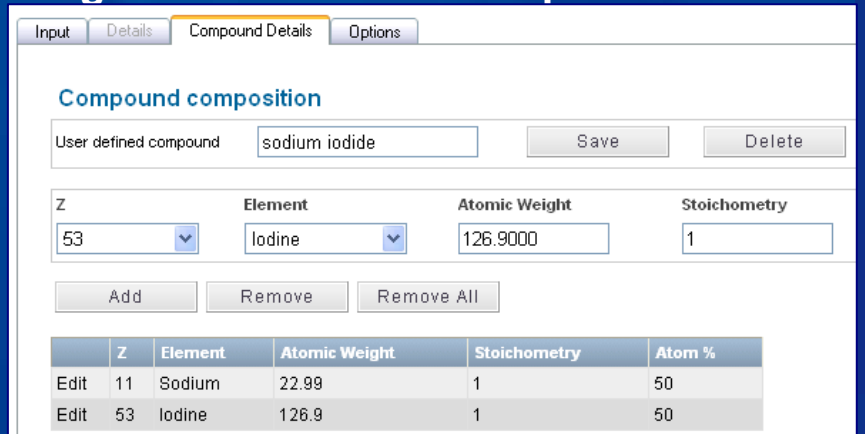
Target: Mono-elements:



Main Interface:



Target: User-Defined Compounds:



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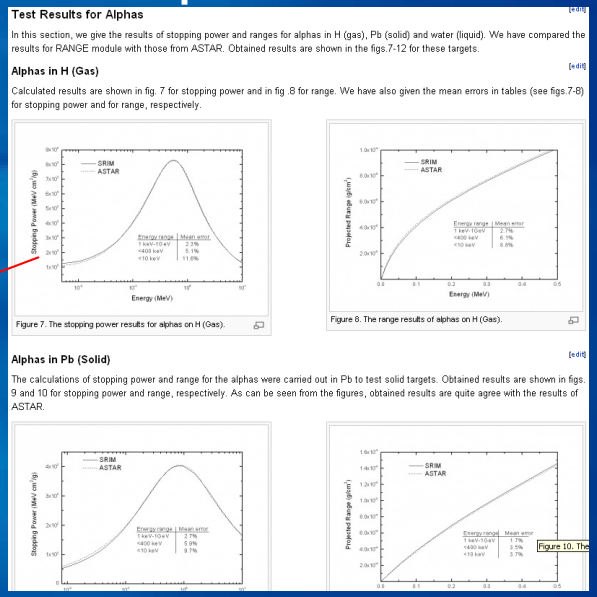
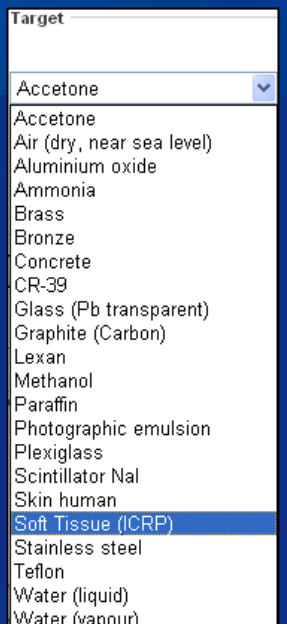


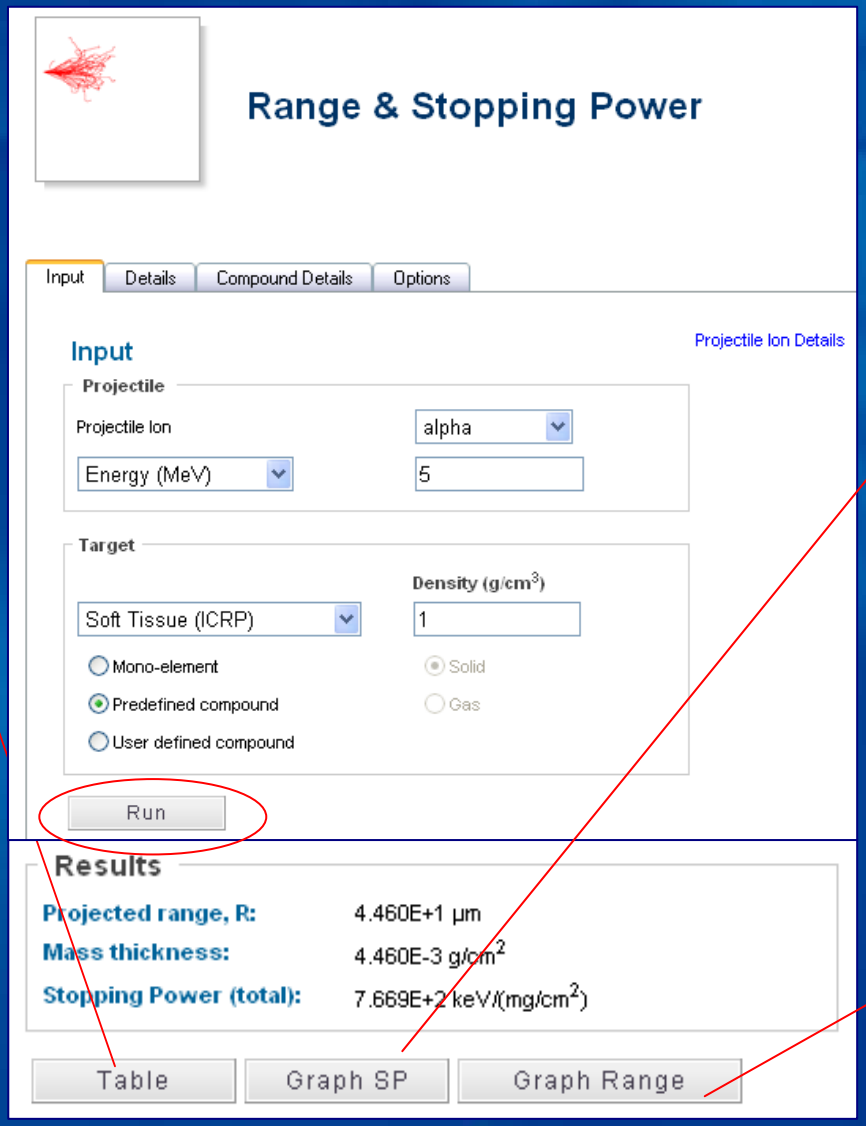
Target: Pre-Defined Compounds:

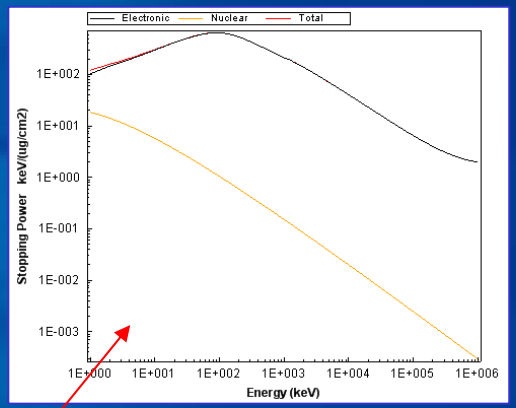


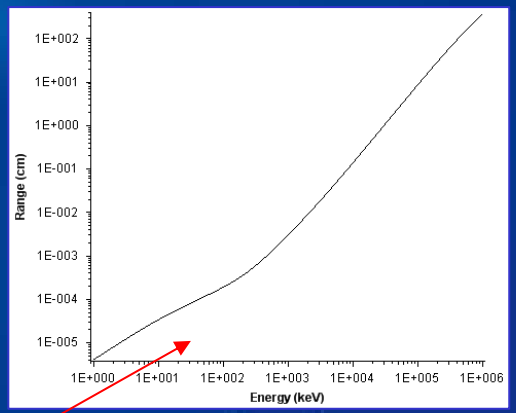
Results:

```
==========================================================
            Calculation using SRIM-2006
            SRIM version --->
            Calc. date   ---> April 07, 2008
==========================================================

Disk File Name = range_out2.txt

Ion = Helium       [2] , Mass = 4.002603 amu

Density =  1.0000E+00 g/cm3 = 4.4282E+22 atoms/cm3
======= Target  Composition ========
   Atom   Atom   Atomic    Mass
   Name   Numb   Percent   Percent
   ----   ----   -------   -------
     H      1    010.45    000.77
     C      6    023.22    020.51
     N      7    002.49    002.56
     O      8    063.02    074.15
    Na     11    000.11    000.19
    Mg     12    000.01    000.02
     P     15    000.13    000.30
     S     16    000.20    000.47
    Cl     17    000.13    000.35
     K     19    000.20    000.57
    Ca     20    000.02    000.07
    Fe     26    000.01    000.02
    Zn     30    000.00    000.01
==================================
Bragg Correction = 0.00%
Stopping Units =  keV/(mg/cm2)
See bottom of Table for other Stopping units

Ion = Helium       [2] , Mass = 4.002603 amu
```

Ion Energy	dE/dx Elec.	dE/dx Nuclear	Projected Range
999.999 eV	9.609E+01	1.382E+02	224 A
1.10 keV	1.008E+02	1.364E+02	246 A
1.20 keV	1.053E+02	1.346E+02	267 A
1.30 keV	1.096E+02	1.328E+02	288 A







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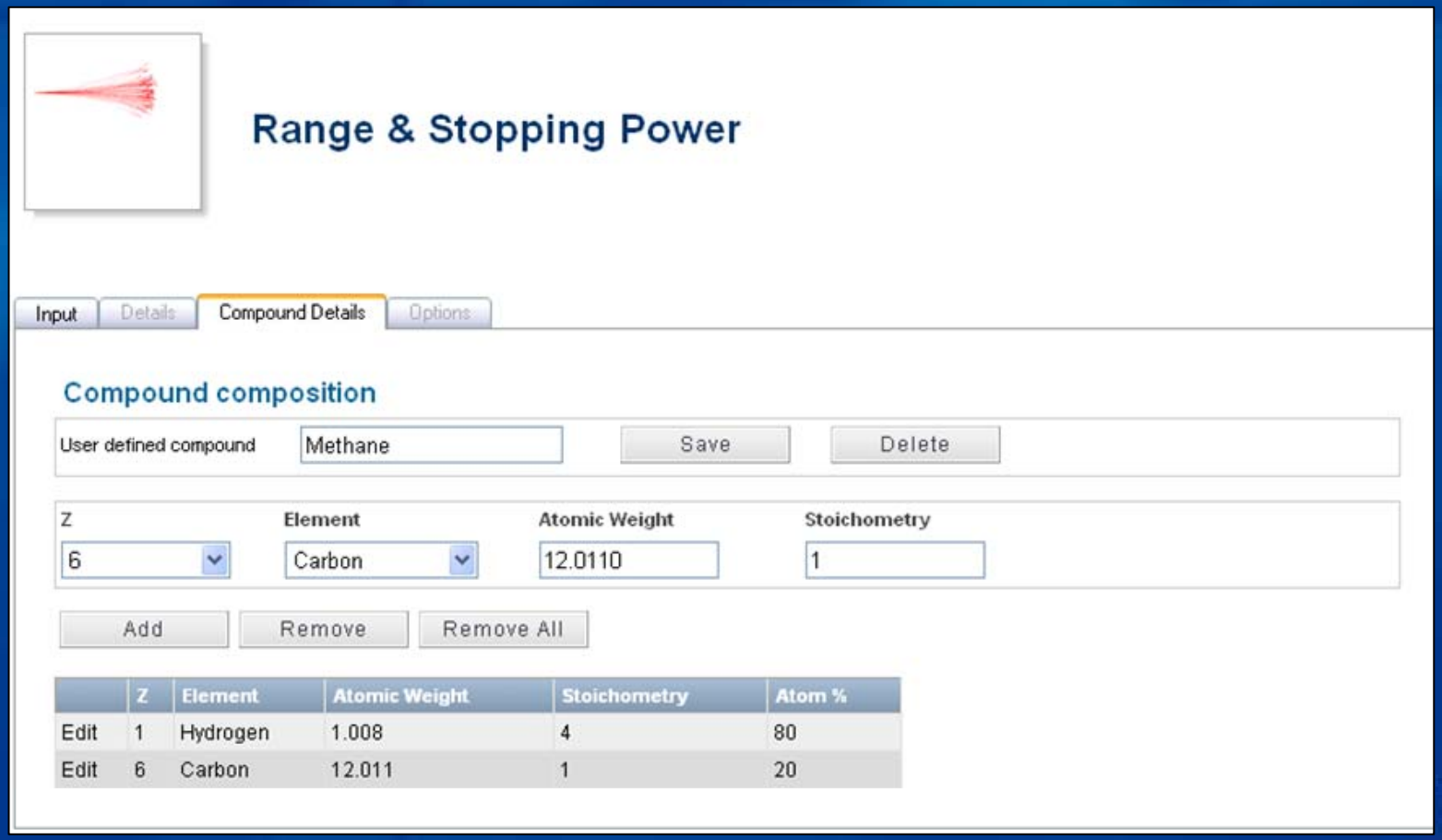
- **Target: User-defined compounds**



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Range Calculations

[edit]

Most of the transport calculations and Monte Carlo simulations for the calculation of Range are based on the so-called Continuous Slowing Down Approximation (CSDA). In this approximation, it is assumed that the particle losses its energy in a continuous way and at a rate equal to the stopping power. Since the stopping power is the energy loss of projectile per unit path, CSDA range (or Bethe range) is calculated by

$$R(E) = \int_{E_{abs}}^{E} \frac{dE'}{S(E')}$$

where E_{abs} is the energy where particle is effectively absorbed. CSDA range is the path length traveled by the particle and since energy-loss fluctuations are not considered, CSDA range is always higher than projected range (R_p) which is the distance between the point where particle enters the stopping medium and the point where particle is absorbed (or come to rest). It becomes important when the projectile's energy is low enough.

SRIM uses PRAL (**P**rojected **R**ange **AL**gorithm) [6] equations for calculating projected range. To second order it involves iterating the difference equation

$$R_p(E_0 + \Delta E_0) = R_p(E_0) + \left[\frac{4E^2 - (2E\mu S_n + \mu Q_n)R_p(E_0)}{4ES_t - 2\mu Q_n}\right]\frac{\Delta E_0}{E}$$

Test Results for Protons

[edit]

We calculated the stopping powers and ranges of H (Gas), Pb (solid) and water (Liquid) for protons and compared the results with PSTAR.

Protons on H (Gas)

[edit]

As can be seen in fig.1, overall agreement with PSTAR is quite good. Comparing the RANGE module's results with PSTAR, the overall mean error in energy range from 1 keV to 1 GeV is 0.8 %, mean error is 1.8 % in energies below 400 keV and mean error in energies below 10 keV is 2.5 %.

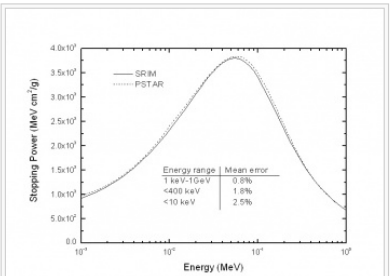

Figure 1. The stopping power results for protons in H (Gas).

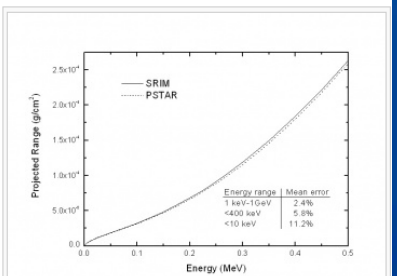

Figure 2. The range results of protons in H (Gas).

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Range and Stopping power

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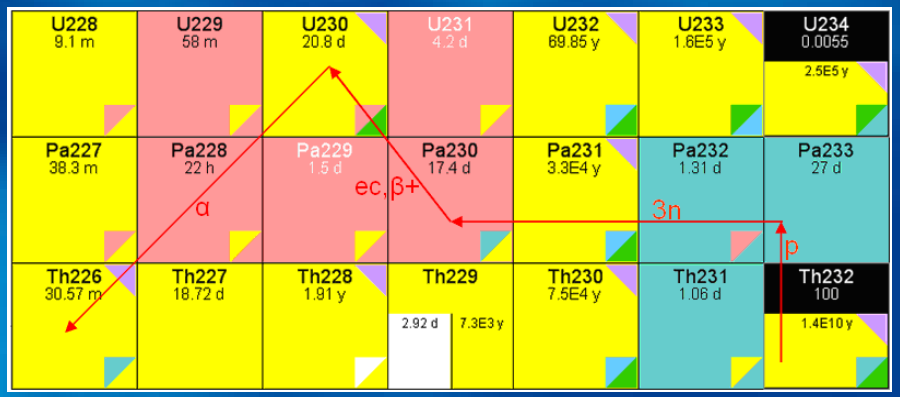
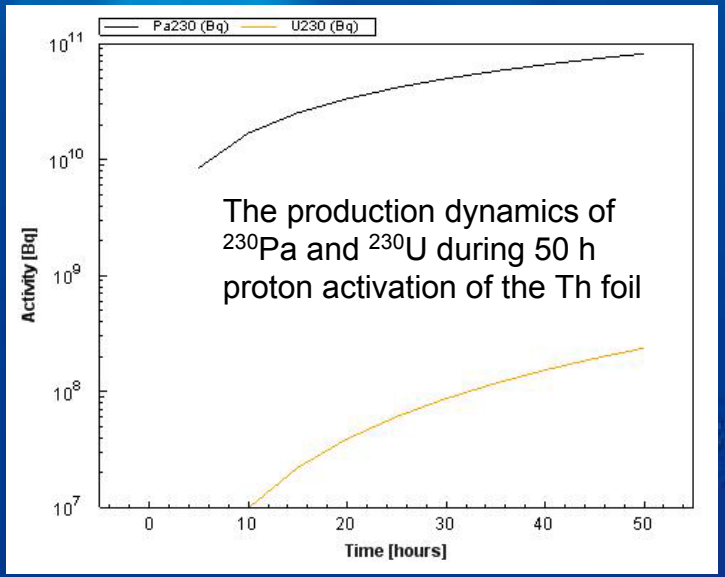
Range Calculations with Nucleonica Scripting

Scripting language:

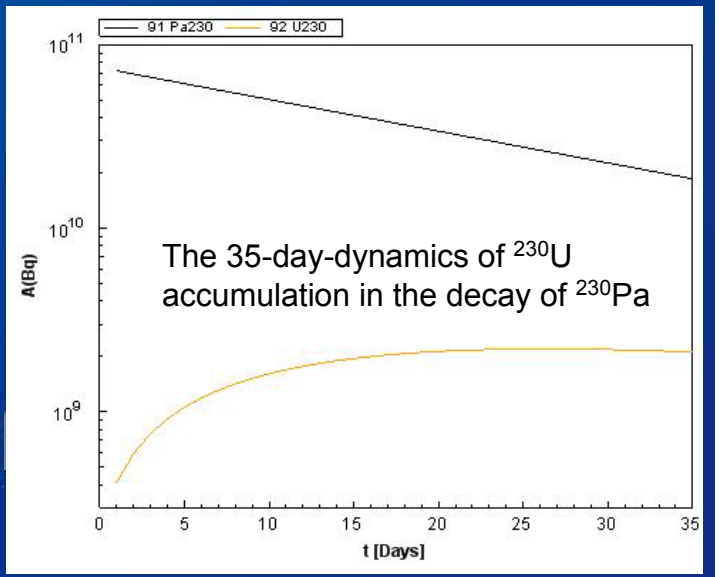
Classes	Main Methods
range	*CalculateMono()*
	CalculateCompound()
	CalculatePredefinedCompound()
	AddCompound()
	OriginConfigureSP()
	OriginGraphSP()
	OriginConfigureRange()
	OriginGraphRange()
rangeResult	*ProjRange(); massthickness();*
	StragLong(); StragLat(); etc.

Case Study: The isotope pair $^{230}U/^{226}Th$ as a candidate for targeted alpha therapy - optimization of ^{230}U production





The production dynamics of ^{230}Pa and ^{230}U during 50 h proton activation of the Th foil



The 35-day-dynamics of ^{230}U accumulation in the decay of ^{230}Pa

CONCLUSIONS

- The RANGE module:
- provides a user-friendly interface for quick and accurate calculations on the range and stopping powers of charged particles.
- can calculate SP and Range for electrons, positrons, protons, alphas, muons and heavy ions in a variety of different natural elements, pre-defined and user-defined compounds.
- Test results show agreements of less than 5% for protons and alphas, less than 10% for electrons and positrons, and less than 7% for muons for the total stopping powers and the CSDA Ranges. The Range module uses SRIM for heavy particles with a known accuracy of less than 5%.
- give freedom to the user for selecting the energy and stopping power units.
- provides high quality graphs for SP and Range.
- can be used in the Nucleonica scripting language.

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Step 1: Calculation Mode | Step 2: Reactor / Operation | Step 3: Input Summary and Run | Step 4: Displ

Reactor irradiation — Power / Flux

Decay

Reactor irradiation and decay

Reactor irradiation, cooling, reprocessing and decay

webKORIGEN

Step 1: Calculation Mode | Step 2: Reactor / Operation | Step 3: Input Summary and Run | Step 4: Display Result

Display Results at 6 y for most important nuclides

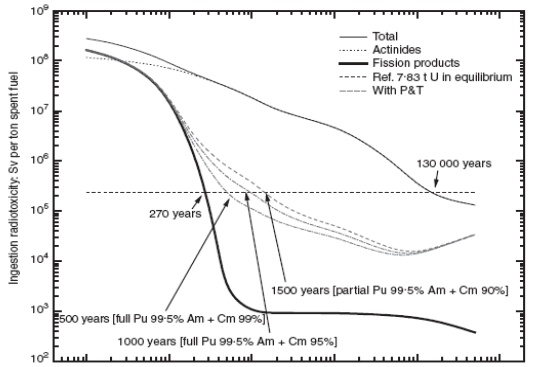
Display quantity: Activity (Bq)

Top Nuclides	Results	Top Elements	Results	Totals	Results
Cs137	1.095E+17	Cesium	1.401E+17	Actinides:	1.130E+17
Ba137m	1.036E+17	Plutonium	1.054E+17	Fission Prod.	4.670E+17
Pu241	9.937E+16	Barium	1.036E+17	Total	5.800E+17
Y90	7.129E+16	Yttrium	7.129E+16		
Sr90	7.127E+16	Strontium	7.127E+16		
Cs134	3.065E+16	Promethium	2.917E+16		
Pm147	2.917E+16	Europium	1.209E+16		
Eu154	9.611E+15	Ruthenium	9.449E+15		
Rh106	9.449E+15	Rhodium	9.449E+15		
Ru106	9.449E+15	Krypton	7.199E+15		
Kr85	7.199E+15	Curium	6.249E+15		
Cm244	6.205E+15	Praseodymium	4.031E+15		
Pu238	5.291E+15	Cerium	3.983E+15		
Ce144	3.983E+15	Antimony	3.670E+15		
Pr144	3.983E+15	Americium	1.313E+15		
Sb125	3.669E+15	Tellurium	8.950E+14		
Eu155	2.477E+15	Neptunium	4.048E+13		
Am241	1.259E+15				
Te125m	8.950E+14				
Pu240	4.933E+14				

Neutron and gamma rates

Neutron rate: 2.491E+10 n/s

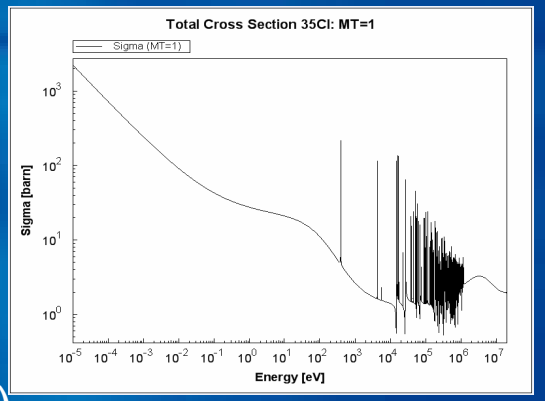
Gamma rate from Actinides: 6.427E+13 MeV/s

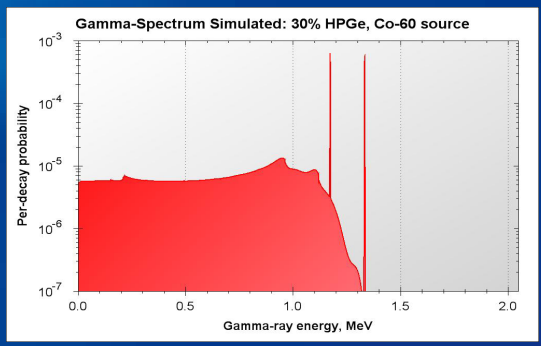


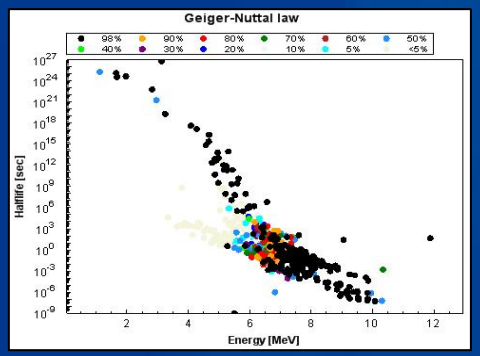
webGraphics…

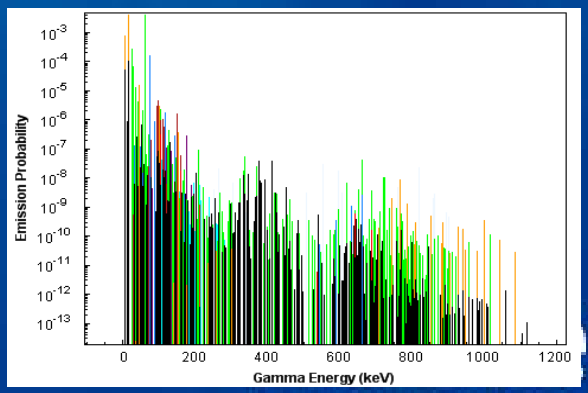
The Nucleonica webGraphics Features:

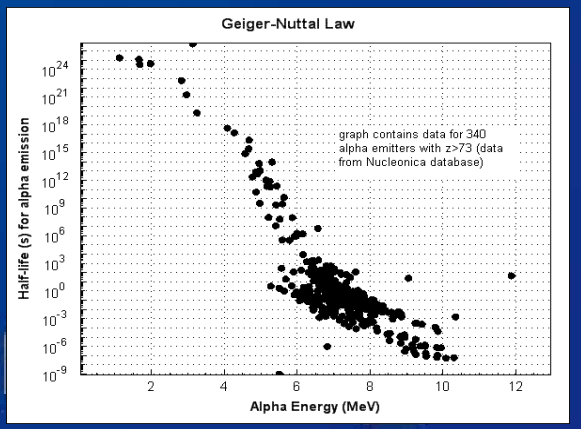
- No need to buy expensive commercial software
- Easy to use
- Delivers publication quality scientific graphs
- Variety of formats available (gif, jpg, emf, eps, png, svg)
- Graphics configuration can be stored for future use
- Available at any time from any location
- Under constant further development











Conclusions: Key Advantages of Nucleonica

- Keep informed with the latest news on nuclear issues
- Use internationally evaluated nuclear data in your work
- Extensive range of nuclear science applications
- Manage all your data in a single browser-based system and keep track of your recent activities
- Prepare a lecture or a training course with Nucleonica materials (graphics. etc.)
- Prepare publication quality scientific graphs
- Stay in contact with your colleagues from previous employment, workshops or conferences
- Meet scientists from your areas of interest and build up an international contact list and represent yourself and your Institute/Organisation in the international science community

nucleonica

Thanks!

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